

ASOS

Attached are two recent papers outlining some of the future development efforts of the ASOS Planned Product Improvement team. These papers provide an overview of the new sensors which will be implemented in the next four to six years. These improved sensors will enable the National Weather Service to provide automated reports of sunshine, reduce the maintenance costs associated with the current dewpoint sensor, provide more accurate reports of precipitation amounts during winter months, and replace obsolete central processor hardware with state-of-the-art equipment. The improved ice accretion logic will allow the ASOS to report critical icing information to many customers such as power companies and aircraft deicing operations.

ASOS

Planned Product Improvement

Briefing for
Workshop for NWS Partners

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Planned Product Improvement

Goals:

- Enhance Capabilities of ASOS
- Enhance Air Safety
- Prolong System Useful Life Beyond 15 Year Expectancy
- Reduce Maintenance Workload

Product Improvement Process

- Concept Exploration - Examine New Technologies
- Sensor Development and field test
- Software Integration
- OT&E
- Production Deployment
- Process takes 5-7 years

Planned Development Activities

- **Sunshine Sensor**
 - Report Number of Minutes of Sunshine
 - Replace 1950's Obsolete Technology
 - Contract awarded
 - Begin deployment mid 2000

- **Dew Point Replacement**
 - Replace Chilled Mirror Technology
 - Improve Sensor Reliability
 - Initial contract awarded
 - Begin deployment early 2002

Planned Development Activities

- Ice Free Wind Sensor
 - No Moving Parts
 - Better Performance In Icing Condition
 - RFP issued April 1999
 - Begin deployment 2002
- All Weather Precipitation Gauge
 - Measure liquid equivalent of snow, ice pellets
 - Begin deployment 2003
- Processor Upgrade
 - Begin deployment 2003

Planned Development Activities

- Enhanced Precipitation Identification Sensor
 - Reports Drizzle, Hail & Ice Pellets
 - Begin deployment 2004
- Ceilometer replacement
 - Current ceilometer out of production
 - Begin deployment 2005

ASOS PLANNED PRODUCT IMPROVEMENTS

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National Weather Service ASOS Program Office
Silver Spring, MD**1. INTRODUCTION**

The National Weather Service is nearing completion of the production phase of the Automated Surface Observing System (ASOS) Program. With over 900 systems successfully deployed across the country, efforts have turned toward upgrading existing meteorological sensors to take advantage of state-of-the-art capabilities. To accomplish this goal, a structured Planned Product Improvement (PPI) process has been implemented.

2. PPI Process

The implementation process for all new sensors consists of five basic steps: concept exploration, procurement and testing of pre-production sensors, software integration, operational test & evaluation, and production deployment.

2.1 Concept Exploration

In this stage, lasting from one-to-five years, new sensor technologies are examined to address system enhancements and new requirements from the user community. Requests for Information (RFIs) and subsequent Requests for Proposals (RFPs) will be issued to procure small numbers of sensors from several vendors. We are looking for 11 proof of concept" i.e., does the sensor meet meteorological requirements. Sensors may be tested at various geographic locations for climatic exposure, particularly winter extremes. Engineering requirements are not a primary concern at this point. However, at the end of this phase a judgement would be made regarding the feasibility of making the sensor ASOS compliant. This stage ends with the development of initial specifications.

Examples of sensors in this phase include the All-Weather Precipitation Accumulation Gauge, the Enhanced Precipitation Identification Sensor and the Ice-Free Wind Sensor.

2.2. Sensor Development and Procurement of Preproduction Article

This stage, lasting from one to three years, begins with the issuance of an RFI. Based on the response, an RFP is developed and issued. The RFP includes ASOS compliant specifications (both meteorological and engineering) and an interface document. In most cases, some developmental effort will be required by the vendor. Award of a subsequent contract would generally be to a single vendor and would include an option for a full production buy. Contractual progress would be monitored with both Preliminary and Critical Design reviews, leading to delivery of sufficient preproduction sensors to perform qualification tests and preliminary integration tests.

Initial testing would be in a "stand-alone" configuration while interfaced to a data acquisition system (DAS). This testing would consist primarily of sensor level testing in a field environment for up to four seasons to validate functional performance, and environmental chamber testing to validate the engineering design. This may be an iterative process with deficiencies being corrected by the vendor based on data from on-site observers using sensor test beds and from engineers using test chambers. Based on the results of the field testing and the environmental testing, a decision on whether or not to integrate the sensor into ASOS will be made.

Examples of sensors in this phase include the replacement Dew Point Sensor and the Sunshine Sensor.

2.3. Integration into ASOS

This stage, lasting up to 18 months, is primarily a software integration effort and can be initiated during the preproduction phase to save schedule time if testing is progressing successfully.

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Using the latest ASOS baseline software supplied by the NWS, the software integration contractor will modify the software modules as required and deliver the modified software to NWS for inclusion in a future software upgrade. A Factory Acceptance Test and possibly a System Acceptance Test would be conducted at both the conclusion of the contractor's efforts and prior to the release of the NWS software baseline upgrade.

2.4 Operational Test & Evaluation (OT&E)

An OT&E involving about 20 field sites with differing climatologies and system configurations will be conducted for a period of up to three months, in order to evaluate the fully integrated sensor in a field environment. The length of the OT&E may be changed based on prior experience with the sensor. At the conclusion of a successful OT&E an implementation decision will be made by the appropriate government management committee. A new baseline software load would be released at this time.

2.5 Production Deployment

Production deployment is primarily a budget driven activity, lasting from one-to-three years, with rate of production/deployment tied to available funds.

3. PPI Plans

Three separate efforts have been identified as the highest priorities for the National Weather Service. An automated sunshine sensor is being procured to replace the currently fielded 1950's vintage manual sensor. A replacement for the existing dew point sensor is being procured to eliminate many of the maintenance problems with chilled mirror technology. Sonic wind sensors, with no moving parts, are being considered for system-wide implementation to greatly reduce the data loss caused by frozen sensors. Additionally, efforts are underway to upgrade the communications and processing capabilities of the ASOS. For the longer term, gauges capable of accurately measuring all forms of precipitation, and sensors capable of detecting drizzle, ice pellets and hail are being explored.

3.1 Sunshine Sensor

In August 1998, a contract was entered into with EKO Instruments of Tokyo for the production of ASOS specification compliant sunshine sensors.

Fully compliant sensors are expected for testing in mid-1999 with initial deployment beginning in early 2000.

3.2 Dew Point Sensor

An RFP for a replacement dew point sensor was issued in mid 1998. Off the shelf sensors from all viable responding vendors will be tested to determine meteorological accuracy and to assess the risk in achieving full compliance (meteorological and engineering) with ASOS specifications. One vendor will then be selected to proceed with full development and eventual nationwide implementation. Current plans are to begin deployment in 2001.

3.3 Ice-Free Wind Sensor

Testing of several promising sonic wind sensors has been underway for about a year at the Sterling, VA Research & Development Center, with additional tests conducted at Cheyenne, WY and Mt. Washington, NH. Current plans are to issue an RFP during 1999 with deployment of a final sensor beginning by 2003.

3.4 Processor Upgrade

Investigation of potential upgrades to the processors and communications capabilities of the ASOS is underway. This update will enable ASOS to fully utilize the more complex emerging sensor technologies, and more rapidly provide critical information. As a part of this effort, high-speed modems have been procured for ASOS systems nationwide.

3.5 Long-Term Activities

Efforts are currently underway to evaluate a ceilometer capable of detecting clouds to 25,000 feet as a replacement to the current 12,000 foot ceilometer. Additionally, new cloud algorithms are being developed to provide more representative observations in fog and snow.

Enhanced precipitation identifiers are being evaluated both at Sterling and at the ASOS winter test facility in Johnstown, PA. The goal is to deploy a replacement sensor that will correctly identify ice pellets, hail and drizzle.

Testing of precipitation gauges capable of accurately measuring the liquid equivalent of frozen precipitation has been underway for the past two

winter seasons at both Sterling and Johnstown. To date, none of the gauges tested have met the meteorological requirements. Further testing of additional sensors will be carried out during the 98-99 winter season.

4.0 Summary

The goal of the ASOS PPI Program is to reduce overall costs to the nation by extending the projected 15year life of the ASOS system well into the 21st century through a phased replacement of individual sensors and components. As a result, system reliability and enhanced public/aviation safety is expected through the integration of thoroughly tested and proven state-of-the-art sensors.

CAPABILITIES OF THE AUTOMATED SURFACE OBSERVING SYSTEM TO QUANTIFY ICE ACCRETION DURING SURFACE ICING EVENTS

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1. INTRODUCTION

The capability for the Automated Surface Observing System (ASOS) to report freezing rain (FZRA) has been under development since the late 1980's. The basic FZRA algorithm for the ASOS was approved in 1995, and over 500 sites are currently instrumented. (Figure 1)

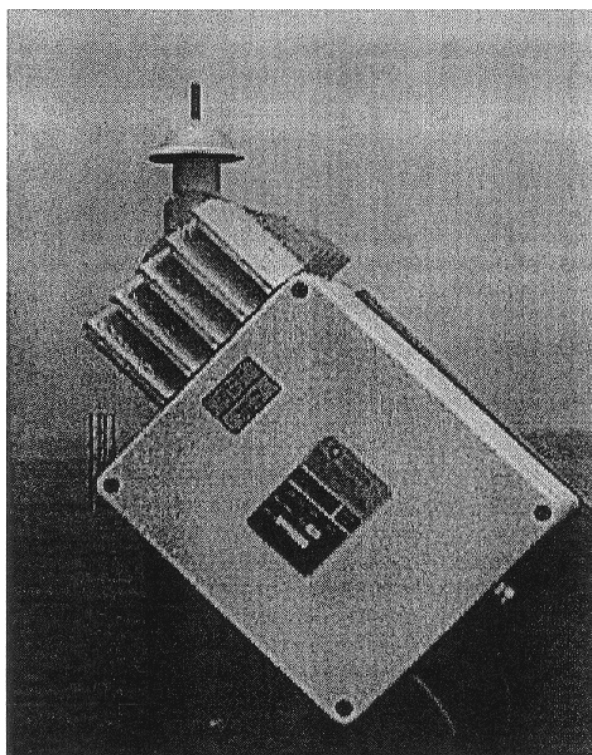


Figure 1 ASOS Rosemount 872C3 Ice Detector

An ASOS Planned Product Improvement effort to provide quantitative surface icing information has been under way since 1995. (Ramsay, 1997; Ryerson and Ramsay, 1997; Ryerson and Ramsay, 1998) This paper provides an update on that Planned Product Improvement, with specific focus on the provision of realtime reports of surface ice accretion.

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2. UPDATED ICE ACCRETION ALGORITHM

Data collection and analysis efforts described earlier (Ramsay and Ryerson, 1997) continued through the winter of 1997-1998, and provided valuable additional ice mass and thickness information. Hourly data collection from continued at Sterling, VA; Johnstown, PA; Binghamton, NY; Cleveland, OH; and Lebanon and Mount Washington, NH.

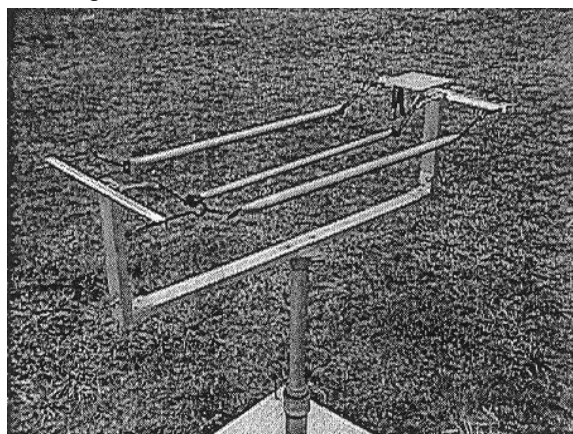


Figure 2 Ice Rack, Rods, and Plate

The previously-reported work established relationships between the "Net Frequency Change" (NFC) reported by the Rosemount sensor and measurements of event-total ice mass on horizontal rods, and the ice mass and thickness on a horizontal aluminum plate. The analysis effort in 1997-1998 was concentrated on hourly, as opposed to event-total, ice accretion. The additional data from five icing events in the winter of 1997-1998 solidified the quantitative relationships established earlier.

Hourly estimates of ice accretion are more sensitive to noise in the sensor data than are the event-total estimates. In an effort to minimize noise in the sensor data, two changes were made to the algorithm:

- The concept of Net Frequency Change was modified slightly to disregard reports of short-period increases in frequency (which occur infrequently, generally when temperatures are near freezing, or when the precipitant is mixed with snow), and

- ❑ The definition of NFC was changed to extrapolate the mean frequency decrease in the fifteen minutes prior to a deicing cycle into the period just after the deicing cycle, when the sensor is known to be "blind" to continuing ice buildup.

These two modifications resulted in a slight change in the relationship between NFC and ice mass on the horizontal rods, but produced no significant change in the relationships between NFC and ice mass and thickness on the horizontal plate. The final relationships between the sensor and *hourly* ice accretion are:

- ❑ On horizontal rods, 32-mm diameter:

$$\text{ICE MASS (g/m)} = 0.15 (\text{NFC})$$

- ❑ On a horizontal metal plate:

$$\text{ICE MASS (g/dm}^2\text{)} = 0.033 \text{ NFC}$$

$$\text{ICE THICKNESS (mm)} = 0.004 \text{ NFC}$$

3. ALGORITHM PERFORMANCE

The proposed algorithm is being evaluated in a series of case studies on events in the 1997-1998 testing season. The following two events (at Binghamton, NY (KBGM), and Burlington, VT (KBTU), in January 1998) are presented as examples of the performance of the algorithm.

The Binghamton event was selected because it is the largest event for which ice mass and thickness measurements were available.

(The different units for ice accretion were selected to satisfy needs of different user communities: g/m for structural icing issues, g/dm² for aircraft deicing activities, and mm for meteorological forecasting or emergency management.)

Figure 3, below, illustrates the relationship between the Net Frequency Change and the hourly change in ice mass on the 32mm-rods. This illustration contains data from the entire test period, from 1995 through 1998. The few data points at

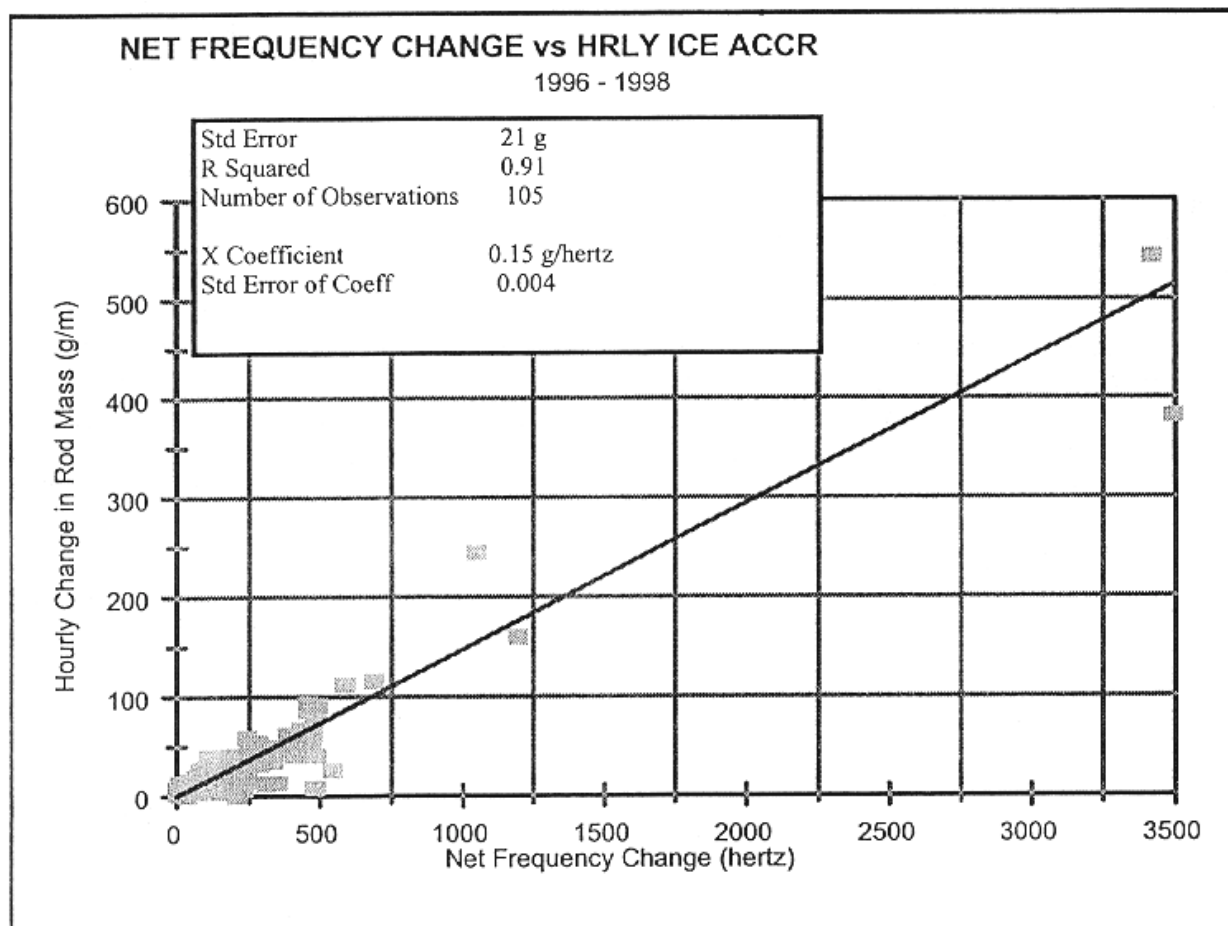


Figure 3 Hourly Ice Accretion and Net Frequency Change

very high ice accretions are from two events in the Spring of 1997 at the summit of Mount Washington.

Considering uncertainties in measurements of ice mass or thickness in the field, and indications of inter-sensor variability from a few events observed with more than one sensor, it is estimated that the uncertainty in these estimates is on the order of 20 to 25 percent.

The Burlington event was selected because it provides an example of what might have been available to forecasters in the northeastern United States during the January 1998 ice storm.

3.1 Icing Event at Binghamton, NY

One moderate icing event was observed during the 1997-1998 testing season. The proportionality between NFC and ice mass was tested against measurements made during the icing event at Binghamton, New York, on January 15-16, 1998.

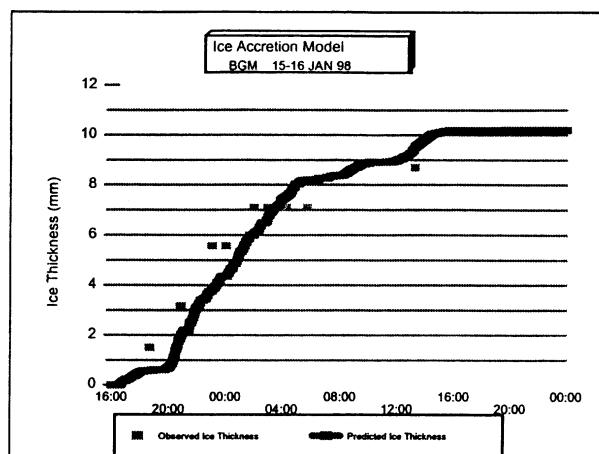


Figure 4 Ice Thickness at Binghamton, NY

The predicted values of ice thickness from the ASOS icing sensor are shown in Figure 4, along with the hourly measurements of ice thickness.

3.2 Icing Event at Burlington, VT

The National Climatic Data Center was able to download a nearly-complete set of raw sensor data from the ASOS at Burlington, Vermont, during the January 1998 ice storm. The data were complete from January 6 through 2120 LST on January 8; this data set did not cover the entire duration of the storm, but it provided enough data to give a good example of the kind of information that the proposed algorithm could have provided. Figures 5 and 6 show a time history of the modeled ice thickness at Burlington.

The ASOS algorithm would have predicted approximately 27 millimeters of ice at Burlington,

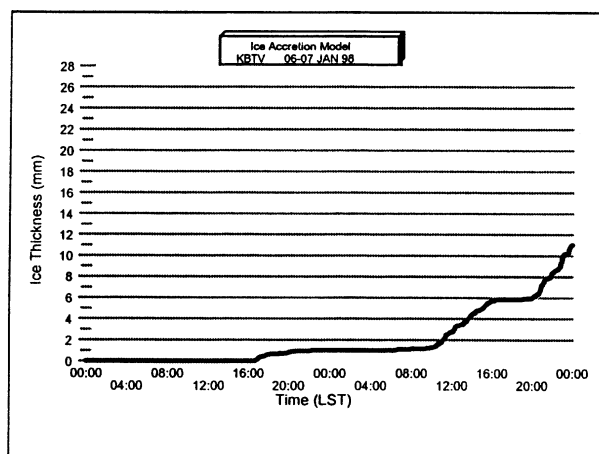


Figure 5 Ice Thickness at KBTX, 6-7 January 1998

even with a loss of over 8 hours of data overnight on January 8-9. NWS personnel at Burlington estimated total ice thickness for the event at "somewhere between 1" and 1 1/2" (Sisson, 1998).

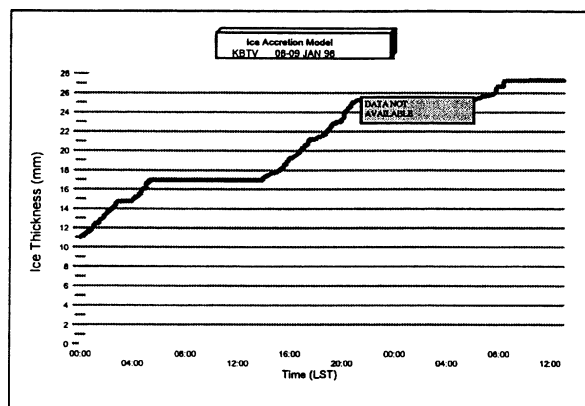


Figure 6 Ice Thickness at KBTX, 8-9 January 1998

4. SUMMARY

The proposed ASOS icing algorithm offers the potential to provide a broad range of users with information that has never been available. Users would have to be aware of the expected 2025% uncertainty in hourly icing estimates, and should compare that uncertainty with an unknown local spatial variation in ice accretion. If the uncertainty can be accepted, the ASOS could contribute significantly:

- to NWS forecasters and emergency-management agencies in monitoring and forecasting icing events;

- to airlines and airfield operators responsible for aircraft and airfield deicing;

- to transportation agencies responsible for maintenance and control of highways, railroads,

and waterways;

to electrical utilities responsible for re-routing power during threatening icing conditions; and

to structural engineers who would ultimately have a climatology of icing throughout the United States that is based on objective and reproducible data.

5. THE FUTURE: REQUIREMENTS DEFINITION

The National Weather Service Office of Meteorology has not established a requirement for this automated capability, and for that reason no product development or initial software development is planned.

The definition of a requirement for quantitative ice accretion information will have to include answers to the following:

What units should be used for reporting ice accretion (e.g., accretion in inches, millimeters, or g/dm²; rates in g/dm²/hr or as light, moderate, heavy)?

What values should be reported (e.g., accretion in the current hour, analogous to the METAR/SPECI "P" group)?

Do users need the beginning and ending time of icing events (analogous to METAR/SPECI precipitation remarks)?

Do users in the meteorology or aviation community have a need for icing rate information? For rime or frost events? Should icing-rate estimates be limited to on-site dissemination, or should they be transmitted long-line?

Do users want information on the sublimation phase of FZFG or FROST events?

Should quantitative ice accretion estimates from this algorithm be combined in a METAR/SPECI remark with icing type derived from a proposed multi-sensor ASOS algorithm? (Ramsay, 1999)

Pending formal definition of a requirement, this ice accretion algorithm will undergo another winter season of field evaluation with detailed measurements from the established network, and with an expanded effort on quick-response case studies from any ASOS in an icing environment.

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